Advanced Information Systems Technology

Simulation-Based Uncertainty Quantification for Atmospheric Remote Sensing Retrievals

Completed Technology Project (2017 - 2019)

Project Introduction

The project will develop a data-centric technology consisting of statistical methods and analysis software to facilitate uncertainty quantification (UQ) for atmospheric remote sensing products, specifically Level 2 data products produced by operational retrieval algorithms. In this very common retrieval setting, an instrument (OCO-2, AIRS, and upcoming missions like Hyspiri and OCO-3) observes a radiance spectrum characterizing the atmospheric composition, and the retrieval algorithm converts the radiance into a quantity of interest, such as temperature, water vapor, or CO2 concentration. The framework we propose relies on Monte Carlo simulation by assembling an ensemble of true atmospheric states, generating synthetic radiances from an appropriate forward model, and performing an operational retrieval. Mission algorithm teams can typically generate these datasets, and our tools will allow the investigation of the retrieval error distribution. In addition, the full collection of true states, radiances, and retrieved state can be summarized in this framework. The UQ tools will include the capability to summarize the correlation in retrieval errors for different components of the state vector. This correlation structure is particularly relevant for applications that use Level 2 for further inference, such as flux estimation in carbon cycle science. This capability relies on characterizing state vector ensembles with heterogeneous constituents. For example, a particular use case might require a state that includes a combination of temperature and humidity profiles, along with surface properties and cloud information. The team will build on experience with simulation-based UQ applied to individual retrievals for the optimal estimation retrieval used by OCO-2. The proposed tools can be infused into a variety of retrieval systems, as long as an appropriate model for generating radiances given true atmospheric states is available. We will implement the methodology with the AIRS Level 2 algorithm as a use case. The UQ framework provides valuable information about sources of uncertainty, such as cloud clearing, that are unique to this retrieval and hard to grapple with using conventional technologies. Further, the proposed framework can be used as a data-centric technology for contrasting uncertainties from different retrievals that are estimating the state of the same true atmosphere.

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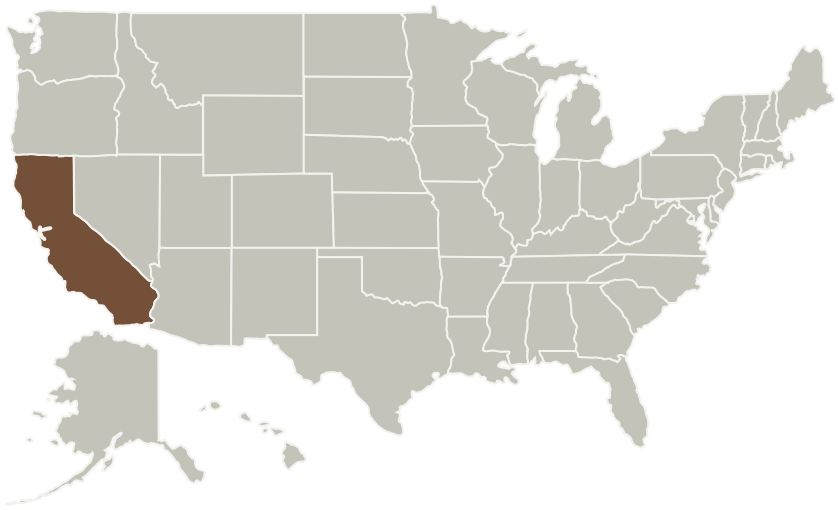
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
California Institute of Technology(CalTech)	Lead Organization	Academia	Pasadena, California

Primary U.S. Work Locations
California

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

California Institute of Technology (CalTech)

Responsible Program:

Advanced Information Systems Technology

Project Management

Program Director:

Pamela S Millar

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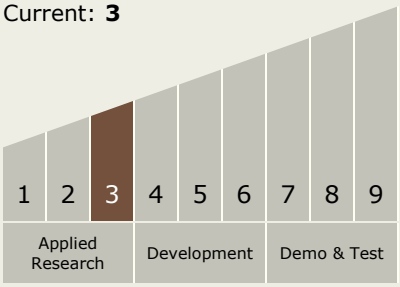
Technology Maturity (TRL)

Start: **3**
Current: **3**



Technology Areas

Primary:

- TX11 Software, Modeling, Simulation, and Information Processing
  - TX11.3 Simulation
    - TX11.3.6 Uncertainty Quantification and Nondeterministic Simulation Methods

Target Destination

Earth